

AN ENGINEERING STUDY
FOR THE
REMOVAL AND DISPOSITION OF PCB CONTAMINATION
IN THE
WAUKEGAN HARBOR AND NORTH DITCH
AT
WAUKEGAN, ILLINOIS

SECOND ADDENDUM TO FINAL REPORT

SUBMITTED TO:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION V
CHICAGO, ILLINOIS

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ADDENDUM SUMMARY

The Mason & Hanger report submitted to the U. S. Environmental Protection Agency in January 1981 and amended in May 1981 has been updated to include the results of 7 additional Waukegan Harbor, Waukegan, Illinois, core borings taken in September 1980. These core borings were taken to further define polychlorinated biphenyl contamination in Waukegan Harbor. The January 1981 estimate of the amount of PCB in Waukegan Harbor has been revised and the estimated amount of PCB in the deep sand and clay sediments near the former Outboard Marine Corporation outfall has been included in this addendum.

A summary of the estimated quantities follows:

	<u>January 1981 Report</u>	<u>May 1981 Addendum</u>	<u>March 1982 Addendum</u>
Total Contaminated			
Muck:			
Cubic Yards	183,670	Not Shown	183,563
Pounds PCB*	221,234	Not Shown	174,358
Total Contaminated			
Sands, Clay:			
Cubic Yards	800 to 2,000	3,700	3,700
Pounds PCB*	20,000 to 50,000	138,000	138,000
Grand Total:			
Cubic Yards	184,470 to 185,670	Not Shown	187,263
Pounds PCB*	241,234 to 271,234	Not Shown	312,358

NOTE: The January 1981 Report states:

"*The pounds of PCB may vary by an order of magnitude depending upon how core borings are grouped and averaged."

1.0 INTRODUCTION

Late in 1980, Mason & Hanger-Silas Mason Co., Inc., Lexington, Kentucky, completed an engineering study for the U. S. Environmental Protection Agency on removal or otherwise treating the polychlorinated biphenyl (PCB) contaminated soils and sediments in and near Waukegan Harbor, Waukegan, Illinois. The final report for this study was submitted to the US-EPA in January 1981. That January 1981 report described the extent of PCB contamination in Waukegan Harbor. The contamination occurred as the result of Outboard Marine Corporation discharging PCBs via an outfall (now sealed off) near the east end of Slip #3 of Waukegan Harbor.

An addendum to the January 1981 report was submitted to the US-EPA in May 1981. The May 1981 addendum report described PCB contamination near the old Slip #3 outfall, based on the information obtained from twelve new deep core borings into sand and clay sediments. The analytical work for the deep borings had not been completed in time for the January 1981 report.

In 1979, the Environmental Research Group, Inc. (ERG) using EPA sampling equipment collected Waukegan Harbor sediment core samples for PCB analysis. This work is described on pages 27-29 of the Mason & Hanger January 1981 report. On page 29 of that report, the following is stated:

"EPA and ERG personnel collected 7 additional sediment samples on September 3-4, 1980. The analysis results were not available at the writing of this report. A Mason & Hanger employee observed collection procedures and noted (1) that the EPA core sampler easily penetrated the top muck sediments coming to rest on the underlying sand or clay, and (2) the core length was less than the muck thickness at the sample location. Because core sample recovery was less than 100% (sometimes as little as 30%), core sample length information could not be used to estimate the depth of a sample segment or thickness of the muck layer."

The US EPA has asked Mason & Hanger to combine the analysis results of these 7 additional sediment core samples with the previously compiled amounts and locations of PCB contamination data. The following sections of the Mason & Hanger January 1981 report are, therefore, updated as this second addendum:

Section 3.2.2.6, page 27-29
Section 3.2.3.2, paragraph 3, page 32
Section 3.2.5.1, page 38, 39, 42
Figure 11, page 40
Table 2, page 41
Section 3.2.5.2, page 42
Appendix 1, Section 3.4, page 18, 19
Appendix 1, page 24-23
May 1981 Addendum, page 4

2.0 DESCRIPTION OF WAUKEGAN HARBOR SEDIMENT SAMPLES COLLECTED IN SEPTEMBER 1980

The analysis results of the seven Waukegan Harbor sediment samples collected on September 3, 1980 are presented at the end of this report under the title "Waukegan Harbor Contamination Data".

A Mason & Hanger employee accompanied EPA and ERG personnel while the seven samples were being collected; Mason & Hanger measured the water depth to top of muck, water depth to top of sand or clay, sediment core length collected, and sediment depth collected for these seven samples. A description of this activity is presented in Appendix 1 of the Mason & Hanger January 1981 report. The measurements showed that less than 100% recovery was obtained on the core samples:

<u>Location</u>	<u>EPA Designation</u>	<u>Sediment Depth Penetrated</u>	<u>Core Length</u>	<u>Percent Recovery</u>
E28	S01 Station 28	4.35'	3.1'	71.3%
E29	S02 Station 29	2.8'	1.5'	53.6%
E29A	S03 Station 29A	4.4'	1.61'	36.6%
E30	S04 Station 30	0.2'	0.2'	100%
E31	S05 Station 31	1.95'	1.6'	82.1%
E32	S06 Station 32	3.8'	2.75'	72.4%
E33	S07 Station 33	10.4'	5'	48.1%

Additional core samples and depth comparison measurements were completed at Mason & Hanger request on September 4. These samples were not saved for analysis. A description of the September 4 activity is also presented in Appendix 1 of the January 1981 Mason & Hanger report.

The core samples collected on September 3 were sectioned into approximately 5 cm. segments for individual analysis of PCBs.

The PCB analysis results were communicated orally to Mason & Hanger during the final stages of preparation and typing of the January 1981 report, but were not included in that report because of (1) the percent solids (percent moisture) information was not yet available and (2) there was a discrepancy in the sighting of E29A, E32, and E33. The correct location of these points is shown in the pocket insert of this addendum report.

Mason & Hanger also reviewed all previous Waukegan Harbor analysis results and recalculated average concentrations and quantities of PCB. Core sample locations for which PCB was not analyzed or otherwise published were deleted in the revised pocket insert of this addendum report. A few points such as WZY-1 were also relocated based on better sighting information. An additional data point (H12) was incorporated into the PCB calculation for areas D2 & D3.

One problem encountered in this review has been location of sample point ERG-5 containing an average PCB concentration of 37,598 ppm; ERG-5 is near the boundary of A3 and A4. The Mason & Hanger January 1981

report sighted ERG-5 in area A4 but the Table 2 on page 41 estimated PCB amounts as if ERG-5 were in area A3. This addendum report computes an average PCB concentration as if A3 and A4 were one unit. The result of this paper maneuver has been to decrease total pounds of PCB in area A3 and increase pounds of PCB in area A4. Again, this illustrates what was said in the January 1981 report, that estimates of pounds of PCB depend upon how data are grouped and averaged.

3.0 COMPUTATION OF PCB QUANTITIES

Figure 11 (page 40) and table 2 (page 41) of the Mason & Hanger January 1981 report have been updated to include the results of the deep core borings B1 thru B12 described in the previous addendum report (May 1981) and the 7 core borings described in this report. The quantity of PCBs were calculated from the following formula:

$$\text{Pounds of PCB} = C S Y D (27)(10)^{-8}$$

Where C = average concentration of PCBs in ppm (dry weight basis) within area A1, A2, A3, etc.

S = average percent solids within same area.

Y = cubic yardage of muck sediment (or sand or clay) within that area.

D = density of sediment (89.7 lbs. per cubic foot for muck; 110 lbs. per cubic foot for sand or clay).

The computations were applied separately to muck, sand, and clay sediments. For example, core segments S01-1 through S01-13 at location E23 were averaged to obtain a PCB concentration of 15416 ppm and a percent solids of 48.1 ppm. This was in turn averaged with the average of the core segments at locations ERG 3, ERG 3D, and E29A to obtain an overall average of 31318 ppm PCB and a percent solids of 53 percent. Core borings segments S01-14 thru S01-16 as well as B1 thru B12 were not included in this set of computations because they represented sand sediments and not muck. The cubic yardage of muck was calculated by multiplying the area by average muck depth. The average muck depth was calculated by laying an equally-spaced grid over muck depth contours (presented in the January 1981 report) and averaging the depths. For example, the average PCB concentration for Area A2 of the four borings is:

$$(34456 + 75135 + 15416 + 263)/4 = 31313 \text{ ppm}$$

The pounds of PCB for area A2 is:

$$(31313)(53.0)(789)(89.7)(27)(10)^{-8} = 31718 \text{ pounds}$$

This method of analysis has certain weaknesses which are discussed in the January 1981 report. Perhaps the most serious weakness is that core boring locations were not selected on an equally-spaced grid basis and weighted according the muck depth. This type of analysis is preferable

in areas A1, A2, and A3 where most of the PCBs lie. Instead, computations on PCB quantities are based on the results of different researchers taken at different times.

4.0 DISCUSSION

When comparing the revised Figure 11 and Table 2 of this addendum with the same tables in the January 1981 report, the following is noted:

1. There was a significant drop in the estimate of PCBs in area A2 (from 79359 to 31718 lbs.) as the result of averaging in the new information at locations E28 and E29A.
2. The estimates for area A3 and A4 changed because the contribution from data point ERG-5 was split between area A3 and area A4 rather than being included entirely within A3. Also, the new data point E29 lowered the estimate for pounds of PCB in A3 when averaged with previous data. There were also minor changes in data analysis for areas A5 and A6. The net result has been to decrease the estimate of PCB in the muck for areas A1 thru A6 from 211,831 pounds to 167,190 pounds. An estimate for cubic yards of muck in area A1 thru area A6 has been corrected from 7,275 cubic yards to 7,175 cubic yards.
3. The estimates for areas B5 and C3 decreased and the estimate for area C2 increased because of the new data. The estimate for area B2 changed because an incorrect listing for average percent solids was discovered when reprocessing the original data.
4. The unaveraged data showed one core segment (S06-15 at location E32) containing 130 ppm of PCB in area C2 which is just inside the area shown on figure 7 for sediments containing between 10 and 50 ppm PCB. Several other segments within areas C2 and C3 show PCB concentrations between 50 and 100 ppm.
5. Estimates of cubic yardage of muck sediments remain essentially unchanged (the depth measurements taken in September 1980 had been incorporated in plotting of muck depth contours).
6. Values for PCB contamination in sand and clay have been added.

The limited sampling taken in September 1980 does raise the question whether the very high PCB concentrations near the former Outboard Marine Corporation outfall are decreasing. The September 1980 PCB data appear less than data from earlier sampling. If PCB concentrations are decreasing, the following avenues of dispersal are possible:

1. The very high pool of PCB (over 100,000 ppm) near the OMC outfall may have sunk into the sand and clay. Core borings B1

thru 312 displayed in the May 1981 Addendum show high concentrations of PCB in the sand and clay near the outfall.

2. Some PCBs may be lost through solubilization into the water and volatilization into the air.
3. The muck sediments can move or become dispersed. Several higher concentrations of PCB in areas C2 and C3 suggest movement from the upper part of Waukegan Harbor.

One may question how much PCB is still remaining in Waukegan Harbor. If this information is important, Mason & Hanger suggests additional sampling of muck sediments for PCB analysis. If funding is available, Mason & Hanger suggests subdividing areas A1, A2, A3 and A4 into an equally-spaced grid of say 48 sampling points. The entire muck depth would be sampled for each point. The muck depth would be measured at each point. The entire core collected at each point would be mixed so that only one PCB analysis need be done at each sampling point. The total quantity of PCB in the muck sediments at areas A1 plus A2 plus A3 plus A4 would be calculated as follows:

$$\text{lbs of PCB} = 1/N \sum_{i=1}^N C_i S_i t_i (A)(D)(10)^{-8}$$

Where N = number of sample locations

C_i = mixed (average) concentration of PCB at location i, ppm

S_i = average percent solids at location i

t_i = depth of muck sediments at location i, ft.

A = 30,230 ft.² for areas A1 + A2 + A3 + A4

D = density, lbs./ft.³, of muck sediments

A few locations should also be sampled outside areas A1, A2, A3 and A4. The number of sampling points may be less because locations other than in A1, A2, A3 and A4 contribute a small percentage to the total PCBs.

TABLE 2 (REVISED MARCH 31, 1982)

PCB CONTAMINATION IN SEDIMENTS IN WAUKEGAN HARBOR

CONTAMINATION IN UPPER SEDIMENTS (MUCK)

<u>Location</u>	<u>Average ppm PCB</u>	<u>Average % Solids</u>	<u>Average Depth (ft.)</u>	<u>Amt. of Contaminated Sediment</u>	
				<u>Cubic Yds. Muck</u>	<u>Lbs. of PCB</u>
A1	54,960	69.6	4.73	1,261	116,822
A2	31,318	53.0	2.96	789	31,718
A3	7,446	74.5	1.82	508	6,825
A4	7,446	74.5	1.80	553	7,430
A5	1,737	52.0	2.21	1,125	2,461
A6	538	50.5	2.61	2,939	1,934
Total A1-A6 (Muck)				7,175 cy	167,190 lbs.
B1	183.2	48.9	2.98	5,510	1,195
B2	152.1	41.1	4.95	11,550	1,749
B3	96.6	45.6	4.28	14,825	1,582
B4	103.2	52.8	3.25	3,792	500
B5	30.0	50.9	1.16	1,890	82
Total B1-B6 (Muck)				37,567 cy	5,108 lbs.
C1	18.2	35.3	3.23	11,355	187
C2	18.8	59.3	2.63	15,219	414
C3	13.6	53.3	4.61	25,253	443
C4	19.7	46.6	5.7 est.	23,351 est.	519
C5	13.3	53.9	3.7 est.	34,958 est.	607
C6	12.0	58.2	2.65 est.	9,815 est.	166
Totals C1-C6 (Muck)				120,451 cy	2,336 lbs.
D1	9.7	75.2	0.5 est.	2,200 est.	39
D2	6.3	75.4	2.0 est.	7,637 est.	37
D3			1.0 est.	8,533 est.	98
Total D1-D3				18,370 cy	224 lbs.
Overall Totals per Muck				183,563 cy	174,858 lbs.

Slip #3 Contamination in Deep Sediments (Sand & Clay)

Cubic yards deep contamination: 2,250 (sand) cy
1,450 (clay) cy

Average PCB Conc. deep contamination: 23,000 ppm (sand)
1,100 ppm (clay)

TABLE 2 (Continued)

Total Amount PCBs in deep Contamination:	138,000 lbs
Total Muck plus sand plus clay:	187,263 cy
	312,858 lbs. PCB

The pounds of PCBs in locations A1, A2, A3 and A4 may vary significantly depending upon how core borings are grouped and averaged.

LOCATION	ESTIMATED CUBIC YARDS SEDIMENT	CALCULATED LBS. OF PCB
A1 TO A6	7,200 (MUCK)	167,000
NEAR OUTFALL	3,700 (SAND, CLAY & FILL)	138,000
B1 TO B5	38,000 (MUCK)	5,100
C1 TO C6	121,000 (MUCK)	2,300
D1 TO D3	18,000 (MUCK)	300

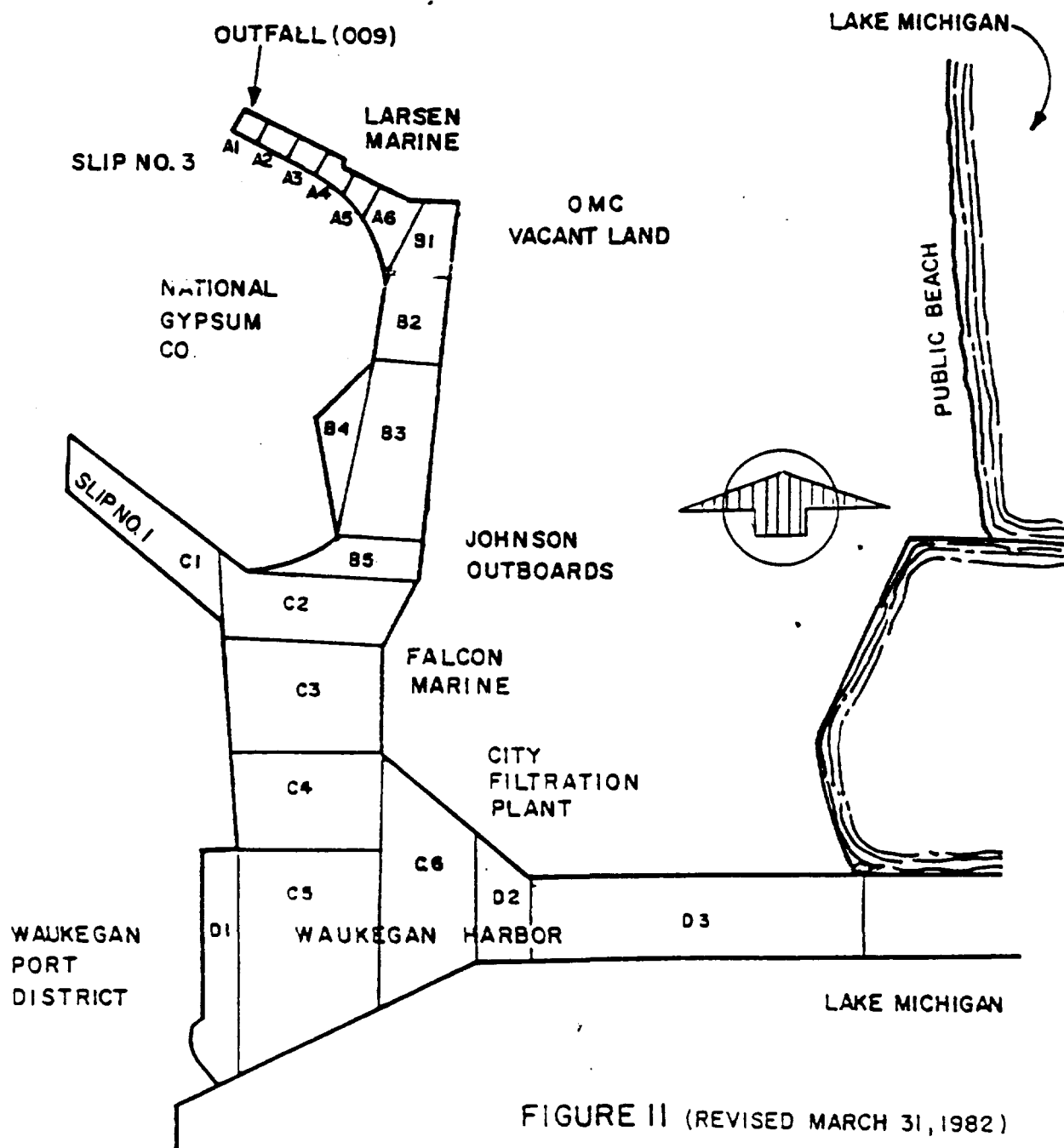


FIGURE II (REVISED MARCH 31, 1982)
EXTENT OF PCB CONTAMINATION IN
SEDIMENT IN WAUKEGAN HARBOR BY AMOUNT

WAUKEGAN HARBOR CONTAMINATION DATA

Sampling performed by: Environmental Research Group, Inc. (ERG), Ann Arbor, Michigan, using US-EPA Sampling Equipment

Data obtained: September 1, 1980

Analysis performed by: Environmental Research Group

Information obtained from: Letter report from ERG to US-EPA dated January 3, 1981

Lake elevation: 579.52'

BORING LOCATION (MASON & HANGER DESIGNATION)	EPA NUMBER	SAMPLE DEPTH	PCB CONTAMINATION ppm as 1242 or 1248	SOIL TYPE	PERCENT MOISTURE	SEDIMENT DEPTH SAMPLED	SAMPLE LENGTH COLLECTED
E28	S01- 1, Sta. 28	567.52'	2100 (1242)	Muck/Water	86.0	4.35' (Total)	3.1' (Total)
E28	S01- 2, Sta. 28		19000 (1242)	Muck	71.7		
E28	S01- 3, Sta. 28		35000 (1242)	Muck	61.3		
E28	S01- 4, Sta. 28		12000 (1242)	Muck	40.2		
E28	S01- 5, Sta. 28		24000 (1242)	Muck	61.4		
E28	S01- 6, Sta. 28		16000 (1248)	Muck	67.1		
E28	S01- 7, Sta. 28		16000 (1248)	Muck	56.8		
E28	S01- 8, Sta. 28		17000 (1248)	Muck	45.5		
E28	S01- 9, Sta. 28		9700 (1248)	Muck	40.2		
E28	S01-10, Sta. 28		17000 (1248)	Muck	41.1		
E28	S01-11, Sta. 28		14000 (1248)	Muck	41.0		
E28	S01-12, Sta. 28		15000 (1248)	Muck	35.9		
E28	S01-13, Sta. 28	563.92'	3500 (1248)	Muck/Sand	27.1		
E28	S01-14, Sta. 28		110 (1248)	Sand	12.7		
E28	S01-15, Sta. 28		7.9 (1242)	Sand	17.5		
E28	S01-16, Sta. 28	563.27' (Sand = 563.9')	2.3 (1248)	Sand	16.2		
E29	S02- 1, Sta. 29	567.72'	1100 (1242)	Muck/Water	79.6	2.8' (Total)	1.5' (Total)
E29	S02- 2, Sta. 29		310 (1242)	Muck	56.3		
E29	S02- 3, Sta. 29		160 (1242)	Muck	50.8		
E29	S02- 4, Sta. 29		220 (1242)	Muck	48.9		
E29	S02- 5, Sta. 29		750 (1242)	Muck	20.3		
E29	S02- 6, Sta. 29		570 (1242)	Muck	40.0		
E29	S02- 7, Sta. 29	563.27'	710 (1248)	Muck/Sand	23.0		
E29	S02- 8, Sta. 29	564.72" (Sand = 565.3')	42 (1242)	Sand	17.7		
E29A	S03- 1, Sta. 29A	568.12'	85 (1242)	Muck/Water	77.7	4.4' (Total)	1.61' (Total)
E29A	S03- 2, Sta. 29A		230 (1242)	Muck	61.0		
E29A	S03- 3, Sta. 29A		160 (1242)	Muck	55.9		
E29A	S03- 4, Sta. 29A		62 (1242)	Muck/Sand	19.8		
E29A	S03- 5, Sta. 29A		640 (1242)	Muck/Sand	21.1		
E29A	S03- 6, Sta. 29A	564.92'	400 (1242)	Muck/Sand	17.5		
E29A	S03- 7, Sta. 29A		8.4 (1242)	Sand	16.3		
E29A	S03- 8, Sta. 29A	563.72'	2.3 (1242)	Sand	16.3		
E30	S04- 1, Sta. 30	556.62'	53 (1242)	Muck/Clay	36.9	0.2' (Total)	0.2' (Total)
E30	S04- 2, Sta. 30		37 (1242)	Clay	20.9		
E30	S04- 3, Sta. 30	556.42' (Clay = 556.6')	15 (1242)	Clay	18.3		
E31	S05- 1, Sta. 31	554.37'	3.4 (1242)	Muck	30.2	1.95' (Total)	1.6' (Total)
E31	S05- 2, Sta. 31		7.2 (1242)	Muck	37.3		
E31	S05- 3, Sta. 31		20 (1248)	Muck	34.3		
E31	S05- 4, Sta. 31		27 (1242)	Muck	44.3		
E31	S05- 5, Sta. 31		3.9 (1242)	Muck	41.3		
E31	S05- 6, Sta. 31		28 (1248)	Muck	42.5		
E31	S05- 7, Sta. 31		16 (1242)	Muck	42.9		
E31	S05- 8, Sta. 31	553.92'	24 (1248)	Muck	40.4		
E31	S05- 9, Sta. 31	552.92' (Sand = 553.3')	50 (1242)	Muck/Sand	46.1		

BORING LOCATION (MASON & HANGER DESIGNATION)	EPA NUMBER	SAMPLE DEPTH	PCB CONTAMINATION ppm as 1242 or 1248	SOIL TYPE	PERCENT MOISTURE	SEDIMENT DEPTH SAMPLED	SAMPLE LENGTH COLLECTED
E32	S06- 1, Sta. 32	559.32'	38 (1242)	Muck	53.5	3.8' (Total)	2.75' (Total)
E32	S06- 2, Sta. 32		18 (1242)	Muck	53.3		
E32	S06- 3, Sta. 32		26 (1242)	Muck	50.3		
E32	S06- 4, Sta. 32		14 (1248)	Muck	52.8		
E32	S06- 5, Sta. 32		12 (1242)	Muck	46.1		
E32	S06- 6, Sta. 32		51 (1242)	Muck	47.5		
E32	S06- 7, Sta. 32		76 (1242)	Muck	58.0		
E32	S06- 8, Sta. 32		44 (1242)	Muck	50.8		
E32	S06- 9, Sta. 32		33 (1242)	Muck	51.1		
E32	S06-10, Sta. 32		54 (1242)	Muck	44.9		
E32	S06-11, Sta. 32		37 (1242)	Muck	42.5		
E32	S06-12, Sta. 32		24 (1242)	Muck	41.5		
E32	S06-13, Sta. 32		33 (1242)	Muck	28.8		
E32	S06-14, Sta. 32		8.2 (1242)	Muck	32.0		
E32	S06-15, Sta. 32		130 (1242)	Muck	43.8		
E32	S06-16, Sta. 32	555.5' (Clay = 555.2')	34 (1242)	Muck	42.4		
E33	S07- 1, Sta. 33		12 (1242)	Muck	58.6	10.4' (Total)	5' (Total)
E33	S07- 2, Sta. 33		13 (1242)	Muck	62.3		
E33	S07- 3, Sta. 33		14 (1242)	Muck	60.3		
E33	S07- 4, Sta. 33		20 (1242)	Muck	63.4		
E33	S07- 5, Sta. 33		17 (1242)	Muck	64.9		
E33	S07- 6, Sta. 33		20 (1242)	Muck	62.0		
E33	S07- 7, Sta. 33		9.0 (1248)	Muck	64.5		
E33	S07- 8, Sta. 33		10 (1248)	Muck	63.2		
E33	S07- 9, Sta. 33		5.1 (1248)	Muck	63.1		
E33	S07-10, Sta. 33		3.5 (1248)	Muck	60.3		
E33	S07-11, Sta. 33		2.4 (1248)	Muck	59.4		
E33	S07-12, Sta. 33		6.1 (1248)	Muck	62.6		
E33	S07-13, Sta. 33		12 (1248)	Muck	55.6		
E33	S07-14, Sta. 33		11 (1248)	Muck	54.0		
E33	S07-15, Sta. 33		35 (1248)	Muck	61.6		
E33	S07-16, Sta. 33		38 (1242)	Muck	59.5		
E33	S07-17, Sta. 33		12 (1248)	Muck	62.2		
E33	S07-18, Sta. 33		54 (1248)	Muck	64.0		
E33	S07-19, Sta. 33		52 (1248)	Muck	63.4		
E33	S07-20, Sta. 33		51 (1248)	Muck	60.3		
E33	S07-21, Sta. 33		26 (1248)	Muck	62.2		
E33	S07-22, Sta. 33		34 (1248)	Muck	62.6		
E33	S07-23, Sta. 33		8.3 (1248)	Muck	62.7		
E33	S07-24, Sta. 33		17 (1248)	Muck	58.3		
E33	S07-25, Sta. 33		23 (1248)	Muck	56.7		
E33	S07-26, Sta. 33	551.52' (Clay = 551.6')	21 (1248)	Muck	55.0		